

## NASTRAN MIGRATION TO UNIX

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## ABSTRACT

COSMIC/NASTRAN, as it is supported and maintained by COSMIC, runs on four main-frame computers - CDC, VAX, IBM and UNIVAC. COSMIC/NASTRAN on other computers, such as CRAY, AMDAHL, PRIME, CONVEX, etc., is available commercially from a number of third party organizations. All these computers, with their own one-of-a-kind operating systems, make NASTRAN machine dependent. The job control language (JCL), the file management, and the program execution procedure of these computers are vastly different, although 95 percent of NASTRAN source code was written in standard ANSI FORTRAN 77.

The advantage of the UNIX operating system is that it has no machine boundary. UNIX is becoming widely used in many workstations, mini's, super-PC's, and even some main-frame computers. NASTRAN for the UNIX operating system is definitely the way to go in the future, and makes NASTRAN available to a host of computers, big and small.

Since 1985, many NASTRAN improvements and enhancements were made to conform to the ANSI FORTRAN 77 standards. A major UNIX migration effort was incorporated into COSMIC NASTRAN 1990 release. As a pioneer work for the UNIX environment, a version of COSMIC 89 NASTRAN was officially released in October 1989 for DEC ULTRIX VAXstation 3100 (with VMS extensions). A COSMIC 90 NASTRAN version for DEC ULTRIX DECstation 3100 (with RISC) is planned for April 1990 release. Both workstations are UNIX based computers. The COSMIC 90 NASTRAN will be made available on a TK50 tape for the DEC ULTRIX workstations. Previously in 1988, an 88 NASTRAN version was tested successfully on a SiliconGraphics workstation.

## INTRODUCTION

The advantage of AT&T's UNIX operating system is that it is an "open system", hardware independent, single and multiuser system, powerful, versatile, and reliable. This "open system", which may appear under different names such as ULTRIX, XENIX, SunOS, AIX etc., is becoming the standard software today for the fast-growing market of workstation computers. Even IBM is going to adopt UNIX for its forthcoming workstations. As many more computers are designed to run under the UNIX banner, these newcomers are getting cheaper, faster, and more powerful. The

result: unprecedented price competition that's making UNIX another word for cheap computing. The migration of NASTRAN to the UNIX "open system", is definitely the way to go.

### THE EARLY DEVELOPMENT

NASTRAN is written mainly in FORTRAN language. Only about five percent of the source codes are machine-dependent. The early stage of migration, started in 1984-1985, was a move towards ANSI FORTRAN 77, which is a standard FORTRAN compiler for all UNIX based computers. In this early stage of development, the NASTRAN UNIVAC version was moved from the 'FOR' compiler to the 'FTN' compiler, and the CDC version from FORTRAN 4 to FORTRAN 5. The VAX NASTRAN had been maintained as a separate version until the 1984 release. This release shared the machine independent source code with the other computers (IBM, CDC and UNIVAC).

### TEST ON SiliconGraphics WORKSTATION

A NASTRAN test program, based on COSMIC/NASTRAN 88 VAX release, was converted and ran "successfully" on a SiliconGraphics workstation. Only occasionally this test program failed in some NASTRAN dynamic problems. Several UNIX job control languages (JCLs) were written to compile, link edit, and execute NASTRAN for this test program. These JCLs played an important part in the success of the SiliconGraphics pilot NASTRAN test. With further refinement and improvement (done in 1989), the JCLs, applicable to all UNIX based computers, play an important role in the NASTRAN migration to UNIX. The JCL to execute a NASTRAN job (cold start, restart or substructuring) is indeed very user friendly.

This SiliconGraphics test program was also used to identify and verify efficiency improvements of the NASTRAN source code. The UNIX utility profiler, prof, was used for timing studies of the codes needing efficiency improvement. These studies resulted in over 30 percent speed improvement of the VAX NASTRAN version. The other NASTRAN versions were also benefited.

All changes that were required to make this SiliconGraphics test program successful, were incorporated into the machine independent NASTRAN source codes.

### VAX NASTRAN

The VAX version of NASTRAN is written entirely in FORTRAN language. Hardware-wise, VAX and many UNIX based computers are quite similar. They are virtual memory computers with 32-bit word architecture. The file management

systems are quite similar. The VAX FORTRAN version is the natural choice for the migration of NASTRAN to the UNIX system.

The NASTRAN GINO (General Input and Output file management) package of the VAX version has gone through extensive revision and improvement in 1987-1988. Many I/O processes have been shortened and streamlined. The packing and unpacking of matrix data were improved and speeded up. The UNIX based computers have therefore benefited from previous VAX improvements. (The improved VAX GINO and matrix packing/unpacking was also tested successfully on an IBM 3084 machine)

The VAX 89 NASTRAN release was compiled and linked successfully on a DEC ULTRIX VAXstation 3100 (with VMS extensions), using the UNIX JCLs from the SiliconGraphics test program. Only one subroutine, CPUTIM that obtains the CPU time from the computer system, needed modification. All 119 NASTRAN demonstration problems, plus 20 more user problems, ran successfully. This NASTRAN UNIX version was officially released on a TK50 tape in October 1989.

The DEC ULTRIX DECstation 3100 (with RISC, Reduced Instruction Set Chip) required additional modification of the NASTRAN source codes. (See next paragraph.) Occasionally this version failed in some dynamic problems, exhibiting the same symptom as that of the SiliconGraphics test program. There will be no official 89 release of this UNIX version. Presently, it is planned to have a 90 NASTRAN release for UNIX based computers with RISC processors.

#### UNIX/FORTRAN REQUIREMENTS

The ANSI FORTRAN 77 is the standard FORTRAN compiler for all UNIX based computers and workstations. However, small differences may exist among ANSI FORTRAN 77 compilers from different manufacturers. The 1990 COSMIC/NASTRAN incorporates many known specifications that are required by various ANSI FORTRAN 77 compilers. The changes involve:

- a. External declaration of bit-shifting functions (LSHIFT and RSHIFT), the logical functions (ANDF and ORF), and complement function (COMPLF), to avoid system functions of the same names.
- b. Standardization of OPEN, READ and WRITE commands for direct-access files.
- c. Removal of octal and hexadecimal constants from FORTRAN executable source code.
- d. Elimination of jumping into an inner do-loop, which was previously allowed via an ASSIGN statement.
- e. Dimension of one for all open core arrays.
- f. Alignment of all open core arrays.

The last change (f) above is the most tricky process for UNIX based computers, particularly those with RISC. Throughout the NASTRAN source code, several hundred labelled commons are used for the open core space. (NASTRAN has no dimension limit. The open-ended open core is used as scratch space for internal computations and storage). The other mainframe computers, particularly the non-virtual CDC and UNIVAC machines, require this open core space to have a unique name in a subroutine or group of subroutines, such that the open core space can be positioned strategically in the executable overlay program. To compromise among the virtual (UNIX based computers, VAX and IBM) and the non-virtual memory computers (that require program overlays), a block data routine, ZZCORE.f, was written to be used only for the UNIX based computers. All the open core labelled commons are included in this block data routine. The labelled common /XNSTRN/ must be the very first in the list, and /ZZZZZZ/ must be the very last. These first and last labelled common requirements must be true not only in the FORTRAN source code, but also in the compiled relocatable (or object) program. The user could use the UNIX command 'nm -n ZZCORE.o' to verify that /XNSTRN/ and /ZZZZZZ/ are positioned correctly. If they are not, something must be done to get the NASTRAN open core alignment correct. It is for this reason (too many labelled commons in one subroutine) that the DEC ULTRIX DECstation 3100 (RISC) uses two block data routines: ZZCORE.f for NASTRAN links 1 through 14, and ZZKORE.f for NASTRAN link 15. It is also for this reason that a C-program, SOROBJ.c, is included in the UNIX NASTRAN release tape, to sort the open core labelled commons in ZZCORE.o (a relocatable file), only if all other efforts fail to obtain the proper alignment.

#### CONCLUSION

The 90 COSMIC/NASTRAN release incorporates many changes as required by the UNIX based computers and workstations. With a set of proven user friendly UNIX JCLs, it should run successfully on many UNIX based computers presently available, or still on the vendors' drawing boards. (FORTRAN compile and link edit are required.) Of course, this 90 COSMIC/NASTRAN release will continue to operate as before on the IBM, VAX, CDC and UNIVAC mainframes. This is a version that bridges from the old world of proprietary and limited operating systems to the new UNIX world of "open system".